New digital methodologies for old grammar problems: Corpus analyses and eye-tracking to discover non-native English article usage preferences

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1.1 Dimensions of English Determiners

• old grammar problems:
  • L1 language without article system (e.g. Chinese) →
  • English article system →
  • difficult to acquire as L2
    (e.g. Huebner 1985; Lardiere 2004; Parrish 1987; Robertson 2000; White 2003; Zdorenko & Paradis 2011)

• dimensions of English determiners
  • definiteness (e.g. Schönenberger 2014)
  • specificity
  • speaker knowledge
  • scope
1.2 Assumptions

- Fluctuation Hypothesis (and Missing Surface Inflection Hypothesis) try to explain L2 linguistic behavior (e.g. Ionin et al. 2004: 8; Prévost and White 2000: 103)
  - overuse of the and a and overuse of zero article, respectively
  - feature awareness of learners
  - full access (transfer) to UG (e.g. Schwartz & Sprouse 1994, 1996)

- Grammaticalization of demonstratives and numerals in Chinese (e.g. Chen 2003, 2004; Huang 1987; Li & Bisang 2012)

- eye-tracking to spot article substitution and omission (or overuse) errors
  - long fixations
  - (regressive) saccades (e.g. Koops et al. 2008; Pickering & Traxler 1998; Roberts & Siyanova-Chanturia 2013)
<table>
<thead>
<tr>
<th>Intro</th>
<th>Lit</th>
<th>Method</th>
<th>Analysis</th>
<th>Conclusion</th>
</tr>
</thead>
</table>

**Literature Review**
2.1 Definiteness and Specificity

If a Determiner Phrase (DP) or the form [D NP] is ...

• [+definite], then the speaker and the hearer presuppose the existence of a unique individual in the set denoted by the NP

• [+specific], then the speaker intends to refer to a unique individual in the set denoted by the NP and considers this individual to possess some noteworthy property (Ionin et al. 2004: 5, Ko et al. 2009: 288)

Example 1: [+definite]
Joan wants to present the prize to the winner...

a) but he doesn’t want to receive it from her. [+specific]

b) so she’ll have to wait around until the race finishes. [-specific]

Example 2: [-definite]
Peter intends to marry a merchant banker...

a) even though he doesn’t get on at all with her. [+specific]

b) though he hasn’t met one yet. [-specific]

(Lyons 1999: 167; example 19)

(Lyons 1999: 176; example 51)
2.2 The Fluctuation Hypothesis

The Fluctuation Hypothesis (FH) for L2 article choice:

a) L2-learners have full access to the features that can underlie article choice cross-linguistically: the features [+definite] and [+specific]/[+partitive].

b) L2-learners fluctuate between dividing English articles on the basis of definiteness vs. specificity, until the input leads them to choose the definiteness option. (Ionin 2003; Ionin et al. 2004: 8)

<table>
<thead>
<tr>
<th>[+definite] (target the)</th>
<th>-definite (target a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>[+specific]</td>
<td>correct use of the</td>
</tr>
<tr>
<td>[-specific]</td>
<td>overuse of a</td>
</tr>
</tbody>
</table>

Table 1. Predictions for article choice in L2-English (Ko et al. 2009: 292)
2.3 Eye-Tracking

• recording of eye movement and non-movement  
  • during reading exercises (Pickering & Traxler 1998; Roberts & Siyanova-Chanturia 2013)  
  • or during associations of e.g. pronunciation and real-world manifestations (Koops et al. 2008)

• focus on learners’ sensitivity to ambiguities and ungrammaticalities (Roberts & Siyanova-Chanturia 2013)

• eye movements: saccades  
  • no new information (Pickering & Traxler 1998)  
  • mean saccade length 7-9 letter spaces (Rayner 2009)

• no eye movement between saccades: fixations  
  • number and duration = text processing  
  • mean fixation length 200-250 ms; word recognition >200 ms (Altmann 2011; Rayner 2009)
2.3 Eye-Tracking

• 10 – 15% of saccades are regressive (Rayner 2009)
  • short regressions = processing difficulty word level
  • long regressions = suggest problems with context integration (Roberts & Siyanova-Chanturia 2013)

• great advantage: early versus late measures
  • early measures (e.g. gaze duration) sensitive to lexical access
  • late measures (e.g. rereading) sensitive to comprehension of text (Roberts & Siyanova-Chanturia 2013)
Fig. 1 Hypothetical eye-movement record. The shaded area represents the region of interest. Figure taken from Roberts & Siyanova-Chanturia (2013: 218).

- **gaze duration**
  - fixations 3 and 4
  - sensitive to syntactic anomalies

- **rereading**
  - fixations 5 and 6
  - occurs after encounter with a problem

(Roberts & Siyanova-Chanturia 2013)
2.3 Eye-Tracking

Fig. 1  Hypothetical eye-movement record. The shaded area represents the region of interest. Figure taken from Roberts & Siyanova-Chanturia (2013: 218).

Fig. 2  Real eye-movement record without an area of interest (AOI).
### 2.4 Deriving the Research Questions

- investigation of FH by e.g. Ko et al. (2009), Hawkins et al. (2006), Snape et al. (2006), and White (2008) using forced elicitation tasks
  - Albrecht (2016, 2017) using corpus data (SYSU-C; compiled by Küchler 2015) and grammaticality judgments
  - overuse of the and a, as well as zero article (FH & MSIH)
    - overuse of a in [+definite] [+specific] contexts (Snape et al. 2006)
    - overuse of the in [+definite] [-specific] and [-definite] [+specific] contexts; as well as with implicit and explicit partitive indefinites (Ko et al. 2009; Hawkins et al. 2006; White 2008)
    - overuse of zero article generally low, esp. in SYSU-C (Albrecht 2016; Chrabaszcz & Jiang 2014; Crosthwaite 2014; Snape 2009)
  - Chinese fluctuate less than predicted by FH, maybe due to grammaticalization (Snape et al. 2006)
- eye-tracking does not rely on participants’ strategic responses (Rayner 2009)
- task conditions force focus to details of input
  - where learner’s processing is most nativelike or (Indefrey 2006)
  - where participants’ idiosyncrasies become influential (Roberts 2012; Roberts & Siyanova-Chanturia 2013: 214)
2.4 Deriving the Research Questions

1. Can the fluctuation patterns found in the literature be reproduced when using a recorded reading exercise instead of forced elicitation?

2. If yes, are the patterns similar to those reported in the literature?
   a. overuse of *a* in [+definite] [+specific] contexts (Snape et al. 2006)
   b. overuse of *the* in [+definite] [-specific] and [-definite] [+specific] contexts (Ko et al. 2009; Hawkins et al. 2006; White 2008)
   c. low overuse of zero article (Chrabaszcz & Jiang 2014; Crosthwaite 2014; Snape 2009)

3. Which social variables do exert an influence (age, gender, years of exposure, education)?
# Data & Methodology
3.1 Data – Set 1: SYSU-C (Chinese Academic Writing)

- SYSU-C issues (Küchler 2015)
  - stratification
  - “dirty data”
  - no POS tags

<table>
<thead>
<tr>
<th>SYSU - corpus</th>
<th>average length</th>
<th>texts</th>
<th>words</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA Theses (Linguistics)</td>
<td>16900</td>
<td>25</td>
<td>422 535</td>
</tr>
<tr>
<td>MA Term Paper (Linguistics)</td>
<td>2500</td>
<td>86</td>
<td>216 278</td>
</tr>
<tr>
<td>MA Term Paper (FL Teaching)</td>
<td>2800</td>
<td>71</td>
<td>200 237</td>
</tr>
<tr>
<td>BA Theses (Linguistics)</td>
<td>11100</td>
<td>2</td>
<td>22 191</td>
</tr>
<tr>
<td>BA Papers (Linguistics)</td>
<td>3000</td>
<td>2</td>
<td>5933</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>186</td>
<td>867 174</td>
</tr>
</tbody>
</table>

Table 2. SYSU – Corpus make-up (Küchler 2015: 105)
3.1 Data – Set 1: SYSU-C (Chinese Academic Writing)

- SYSU-C issues (Küchler 2015)
  - stratification
  - “dirty data”
  - no POS tags

- data cleaning by removing
  - headings
  - remnants of converted captions, graphs or tables
  - encoding errors/general errors

- qualitative analysis via Antconc 3.4.4
3.1 Data– Set 1: SYSU-C (Chinese Academic Writing)

• 200 randomly chosen sentences
  • manually coded for definiteness, specificity, overuse/ substitution errors (the for a) and omission (zero the/a)
  • For example, if we developed (1) cultural empathy excessively, it would result in (2) the over-adaptation to (3) the western culture; [...]. (CMAC05CU_28)
    • (1) [-definite] [-specific]
    • (2) [-definite] [-specific] overuse the for an
    • (3) [-definite] [+specific] overuse the for zero article
3.1 Data – Set 2: Eye-Tracking Experiment

- judgement sample of 20 L1-Russian and 24 L1-Chinese university students
  - 5 - 18 years of learning English
  - 2\textsuperscript{nd} semester
  - focus on young females (b. 1987 – 1997)
  - recorded in 2016

- stratified as to program and gender

<table>
<thead>
<tr>
<th>program/gender</th>
<th>BA</th>
<th>MA</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>4</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>Female</td>
<td>19</td>
<td>13</td>
<td>32</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>23</strong></td>
<td><strong>20</strong></td>
<td><strong>44</strong></td>
</tr>
</tbody>
</table>

Table 3. Data set distribution
3.1 Data – Set 2: Eye-Tracking Experiment

- judgement sample of 20 L1-Russian and 24 L1-Chinese university students
  - 5 - 18 years of learning English
  - 2\textsuperscript{nd} semester
  - focus on young females (b. 1987 – 1997)
  - recorded in 2016

- stratified as to program and gender
  - age range short; no change
  - influence of education
  - (yrs of E) continuous measure for program

<table>
<thead>
<tr>
<th>program /gender</th>
<th>BA</th>
<th>MA</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>4</td>
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</tr>
<tr>
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<td>13</td>
<td>32</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>23</strong></td>
<td><strong>20</strong></td>
<td><strong>44</strong></td>
</tr>
</tbody>
</table>

Table 3. Data set distribution
3.2 Methodological Essentials

• 33 slides to read online
  • one sentence each
  • most containing article misuse

• sentences
  • taken from Ionin et al. (2004) & Ko et al. (2010)
  • similar to previous studies (Chrabaszcz and Jiang 2014; Crosthwaite 2014; Hawkins et al. 2006; Ko et al. 2009; Schönenberger 2014; Snape et al. 2006; White 2008)
  • also taken from SYSU-C

• instructions short
  • read sentences silently
  • try to understand meaning
3.2 Methodological Essentials

• SMI Experiment Suite 3.0
  • experiment set up in Experiment Center 3.3
  • recordings analyzed in BeGaze 3.3

• each article occurrence marks area of interest (AOI)
  • 2371 English article tokens
  • 1214 after data cleaning & cross-tabulation for analysis

• quantitative analysis
  • repeated-measures ANOVA (Ionin 2003, Ko et al. 2009, Ko et al. 2010) in R 3.4.1
  • mixed-effects logistic regression in Rbrul 3.0.2 (Johnson 2009)
Analysis and Discussion
4.1 Qualitative Analysis

- SYSU-C: overuse of *a* in [+definite, -specific] and overuse of *the* in [-definite, +specific] contexts most often (RQ2b):
  - In (1) the article [...], Saillard put forward (2) the doubt about (3) the actual effect of [...]. (CC10FMATP_144)
    - (1) [+definite] [+specific]
    - (2) [-definite] [+specific] overuse of *the* for *a*
    - (3) [+definite] [-specific]
  - Some problems of (1) the language planning in China are also revealed, [...]. (CC10FMATP_154)
    - (1) [-definite] [+specific] overuse of *the* for zero
  - In short, (1) a majority of (2) the participants showed (3) a more critical view in their response on this issue. (CC12FMATP_124)
    - (1) [+definite] [-specific] overuse of *a* for *the*
    - (2) [+definite] [-specific]
    - (3) [-definite] [-specific]
4.1 Qualitative Analysis

• overuse of *a* in [+definite, +specific] fewer occurrences (RQ2a):
  - [...] (1) a majority of (2) the participants (118, or 59.6%) mentioned (3) word and (4) structural usage patterns.  
    - (1) [+definite] [+specific] overuse of *a* for *the* (substitution error)
    - (2) [+definite] [+specific]
    - (3) [-definite] [-specific]
    - (4) [-definite] [-specific]

• omission errors fewest (RQ2c):
  - (1) The first one refers to (2) the status of (3) certain language or (4) certain varieties compared to any other language or variety, deciding (5) the users and (6) the registers.  
    - (1) [+definite] [+specific]
    - (2) [+definite] [-specific]
    - (3) [-definite] [-specific] omission of *a* (overuse of zero article)
    - (4) [+definite] [-specific]
    - (5) [+definite] [-specific]
    - (6) [+definite] [-specific]
4.1 Qualitative Analysis

• summary:

<table>
<thead>
<tr>
<th></th>
<th>[+definite]</th>
<th>[-definite]</th>
</tr>
</thead>
<tbody>
<tr>
<td>correct</td>
<td>93%</td>
<td>94%</td>
</tr>
<tr>
<td>incorrect</td>
<td>7%</td>
<td>6%</td>
</tr>
<tr>
<td>[+specific]</td>
<td>93%</td>
<td>94%</td>
</tr>
<tr>
<td>[-specific]</td>
<td>89%</td>
<td>96%</td>
</tr>
<tr>
<td>11%</td>
<td>4%</td>
<td></td>
</tr>
</tbody>
</table>

Table 5. Article choice in SYSU-C.

• error rate highest in [+definite, -specific], but not in [-definite, +specific] context

• higher level of E proficiency, because of genre (Ac. Writing)?
Fig 3. Gridded AOIs for all respondents (slide 33). Numbers indicate Dwell time average in ms.

However, Chinese might put it differently, as if the grass will feel the pain.
4.2 Quantitative Analysis

• overall results:
  • fixation duration and regressive saccades’ duration do not directly support acknowledgement of article error
  • BUT: if 1st fixation duration >200ms, error “recognition”
  • reason of article salience not necessary (rereading), included as counts
4.2 Quantitative Analysis

- overall results con’t:
  - article omission low (approx. 2%; RQ2c)
  - Russian speakers overall more accurate (grammatic. further?)

<table>
<thead>
<tr>
<th>Languages</th>
<th>[+definite]</th>
<th>[-definite]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>correct</td>
<td>incorrect</td>
</tr>
<tr>
<td>Chinese</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[+specific]</td>
<td>99%</td>
<td>1%</td>
</tr>
<tr>
<td>[-specific]</td>
<td>92%</td>
<td>8%</td>
</tr>
<tr>
<td>Russian</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[+specific]</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>[-specific]</td>
<td>89%</td>
<td>11%</td>
</tr>
</tbody>
</table>

Table 5. Results of the L1-Chinese and L1-Russian respondents
4.2 Quantitative Analysis

- repeated-measures ANOVA:
  - dependent variable: count of “errors” (no or <200ms fixation of article AOI)

<table>
<thead>
<tr>
<th>L1 – Chinese (N=24)</th>
<th>article errors</th>
<th>L1 – Russian (N=20)</th>
<th>article errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definiteness</td>
<td>F(1, 23) = 46.98*</td>
<td>Definiteness</td>
<td>F(1, 19) = 37.92*</td>
</tr>
<tr>
<td>Specificity</td>
<td>F(1, 23) = 13.70*</td>
<td>Specificity</td>
<td>F(1, 19) = 8.25*</td>
</tr>
<tr>
<td>Definiteness * Specificity</td>
<td>F(1, 23) = 36.11*</td>
<td>Definiteness * Specificity</td>
<td>F(1, 19) = 21.67*</td>
</tr>
</tbody>
</table>

Table 6. Effects of definiteness and specificity.

NB: *p<0.05  **p<0.01  ***p<0.001
4.2 Quantitative Analysis

• these results very similar to those of Ionin (2003: 145), Ko et al. (2009: 295), and Ko et al. (2010: 238)
  • specificity and definiteness have significant effects on article usage (definiteness only in St. Englishes)
  • interaction due to greater difference in article use between [+specific] and [-specific] definites when compared to [+specific] and [-specific] indefinites (Ko et al. 2009: 295)
4.2 Quantitative Analysis

- Overall results:
  - Article omission very low (approx. 2%; RQ2c)
  - Russian speakers overall more accurate (grammatic. further?)

<table>
<thead>
<tr>
<th></th>
<th>[+definite]</th>
<th>[-definite]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>correct</td>
<td>incorrect</td>
</tr>
<tr>
<td>[+specific]</td>
<td>99%</td>
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4.2 Quantitative Analysis

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  - interaction due to greater difference in article use between [+specific] and [-specific] definites when compared to [+specific] and [-specific] indefinites (Ko et al. 2009: 295)
  - supports notion of Fluctuation Hypothesis: most errors in contexts where definiteness and specificity in conflict
- investigation of social variables via logistic regression (RQ3)
4.2 Quantitative Analysis

- age, years of exposure to English (YoE), and level of education all correlate strongly
- inclusion of all variables → false positive results
- age & YoE introduce more noise to model than education
  - dependent variable: mistake (binary: yes/no, Appl.V.: yes)
  - fixed effects: L1, gender, program (BA/MA), definiteness, specificity, and complexity
  - random effects: Subject, Area of Interest
- Model w/all respondents (n=1214, AIC=260, $R^2_{\text{fixed}}=0.06$)

<table>
<thead>
<tr>
<th>L1</th>
<th>$p&lt;0.05$</th>
<th>log odds</th>
<th>tokens</th>
<th>application value</th>
<th>cent. factor</th>
<th>weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chinese</td>
<td></td>
<td>0.459</td>
<td>668</td>
<td>0.039</td>
<td></td>
<td>0.613</td>
</tr>
<tr>
<td>Russian</td>
<td></td>
<td>-0.459</td>
<td>546</td>
<td>0.018</td>
<td></td>
<td>0.387</td>
</tr>
</tbody>
</table>

Table 7. Logistic regression results for all respondents (N=44)
4.2 Quantitative Analysis

• age, years of exposure to English (YoE), and level of education all correlate strongly

• inclusion of all variables → false positive results

• age & YoE introduce more noise to model than education
  • dependent variable: mistake (binary: yes/no, Appl.V.: yes)
  • fixed effects: L1, gender, program (BA/MA), definiteness, specificity, and complexity
    • random effects: Subject, Area of Interest

• Model w/all respondents (n=1214, AIC=260, $R^2_{\text{fixed}}=0.06$)
  • Chinese favor article errors significantly; 4% of 668 ($p=0.04$)
  • Russians disfavor it; 2% of 546 ($p=0.04$)

• supports separation (cf. Ko et al. 2009 & 2010)
4.2 Quantitative Analysis

- Russian only (n=546, AIC=99.8, $R^2_{\text{fixed}}=0.38$)
  - same variables
  - significant effects: specificity ($p<0.001$)

Russians favor article errors in [-specific] environments → 4% of 211 tokens
- definiteness, gender, program, sentence complexity insignificant
- however: low average error rate

<table>
<thead>
<tr>
<th>factor</th>
<th>log odds</th>
<th>tokens</th>
<th>application value</th>
<th>cent. factor</th>
<th>weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>non-specific</td>
<td>1.331</td>
<td>211</td>
<td>0.043</td>
<td>0.791</td>
<td></td>
</tr>
<tr>
<td>specific</td>
<td>-1.331</td>
<td>335</td>
<td>0.003</td>
<td>0.209</td>
<td></td>
</tr>
</tbody>
</table>

Table 8. Logistic regression results for Russian respondents (N=20)
4.2 Quantitative Analysis

- Chinese only (n=668, AIC=212.7, $R^2_{\text{fixed}}=0.22$)
  - same variables
  - significant effects: program ($p<0.001$), complexity ($p<0.001$), and specificity ($p<0.001$)

<table>
<thead>
<tr>
<th>factor</th>
<th>factor level</th>
<th>log odds</th>
<th>tokens</th>
<th>application value</th>
<th>cent. factor weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program</td>
<td>BA</td>
<td>0.432</td>
<td>277</td>
<td>0.058</td>
<td>0.606</td>
</tr>
<tr>
<td></td>
<td>MA</td>
<td>-0.432</td>
<td>391</td>
<td>0.026</td>
<td>0.394</td>
</tr>
<tr>
<td>Complexity</td>
<td>complex</td>
<td>0.701</td>
<td>336</td>
<td>0.060</td>
<td>0.668</td>
</tr>
<tr>
<td></td>
<td>simple</td>
<td>-0.701</td>
<td>332</td>
<td>0.018</td>
<td>0.332</td>
</tr>
<tr>
<td>Specificity</td>
<td>non-specific</td>
<td>0.594</td>
<td>280</td>
<td>0.061</td>
<td>0.644</td>
</tr>
<tr>
<td></td>
<td>specific</td>
<td>-0.594</td>
<td>388</td>
<td>0.023</td>
<td>0.356</td>
</tr>
</tbody>
</table>

Table 10. Logistic regression results for Chinese respondents (N=24)
4.2 Quantitative Analysis

- Chinese only (n=668, AIC=212.7, $R^2_{\text{fixed}}=0.22$)
  - same variables
  - significant effects: program ($p<0.001$), complexity ($p<0.001$), and specificity ($p<0.001$)
  - Chinese favor article errors on BA level, in complex sentences in [-specific] contexts in only approx. 6% of cases
  - gender and definiteness do not exert significant effect
  - Russians less mistakes $\rightarrow$ Chinese at earlier stage of L2-English article system proficiency? (similarly to stage of grammatical.)
    $\rightarrow$ semantic concept of specificity seems influential at higher level of proficiency?
4.2 Quantitative Analysis

• Summary
  • RQ1: yes, fluctuation patterns suggested by Hawkins et al. (2006), Ionin (2003), Ko et al. (2009, 2010), White (2008), etc. can be partially reproduced with eye-tracking data
  • RQ2a: no overuse of a in [+definite, +specific] contexts confirmed
  • RQ2b: partially, overuse/substitution errors most common in [+definite, -specific] but not [-definite, +specific] contexts
  • RQ2c: yes, low overuse of zero article
  • RQ3: level of education only social variable exerting influence for Chinese respondents only
Conclusion
5. Conclusion

• hope to have shown
  • new digital methodologies help solve old grammar problems
  • also older methodologies can be transferred into digital space (e.g. online questionnaires)
  • in our special grammar problem of article usage, this would be particularly useful to expand the approaches that try solve a very complex problem (triangulation)
References


Altmann, Gerry T. M. 2011. Language can mediate eye movement control within 100 milliseconds, regardless of whether there is anything to move the eyes to. *Acta psychologica* 137(2). 190–200.


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References III


New digital methodologies for old grammar problems: Corpus analyses and eye-tracking to discover non-native English article usage preferences

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4.2 Quantitative Analysis

• limitations:
  • few data points → more slides
  • more respondents
  • DV duration in ms did not yield significant results, maybe due to fact that function words are usually not read (Roberts & Siy... 2013)